(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

(10) International Publication Number
WO 02/19949 A2

(51) International Patent Classification[7]: A61F 2/10

(21) International Application Number: PCT/US01/28144

(22) International Filing Date:
6 September 2001 (06.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/656,661 7 September 2000 (07.09.2000) US

(71) Applicant *(for all designated States except US)*: **ALLERGAN SALES, INC.** [US/US]; 2525 Dupont Drive, Irvine, CA 92612 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LAGUETTE, Stephen, W.** [US/US]; 92 Seascape, Laguna Niguel, CA 92653 (US). **WEINSCHENK, Joseph, I., III** [US/US]; 6440 Elm Crest Court, Ft. Worth, TX 76132 (US). **LIAO, Charles, X.** [CN/US]; 24 Del Ventura, Irvine, CA 92606 (US). **GHAZIZADEH, Massoud** [US/US]; 24419 Hillsdale Avenue, Laguna Niguel, CA 92653 (US).

(74) Agents: **DONOVAN, Stephen** et al.; c/o Allergan Sales, Inc., 2525 Dupont Drive, Irvine, CA 92612 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

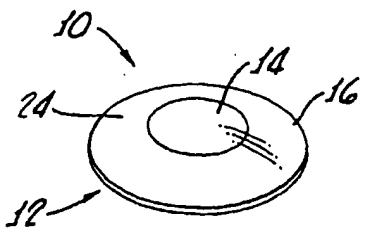
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**
— *without international search report and to be republished upon receipt of that report*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

WO 02/19949 A2

(54) Title: INTRAOCULAR LENS WITH A POSTERIOR LENS PORTION




(57) Abstract: An intraocular lens (IOL) for use in a mammalian eye includes an optic adapted to focus light toward a retina of the mammalian eye and, in cooperation with the mammalian eye, to provide accommodation, the optic including a first portion adapted to move in response to the action of the mammalian eye; and a second portion secured to the first portion and positioned generally in a posterior region of the optic.

# INTRAOCULAR LENS WITH A POSTERIOR LENS PORTION

## Background of the Invention

The present invention relates to intraocular lenses (IOLs). More particularly, the invention relates to IOLs with lens portions, for example, posterior lens portions which are adapted to provide accommodation in the eye.

The human eye includes an anterior chamber between the cornea and iris, a posterior chamber, defined by a capsular bag, containing a crystalline lens, a ciliary muscle, a vitreous chamber behind the lens containing the vitreous humor, and a retina at the rear of this chamber. The human eye has a natural accommodation ability. The contraction and relaxation of the ciliary muscle provides the eye with near and distant vision, respectively. This ciliary muscle action shapes the natural crystalline lens to the appropriate optical configuration for focusing light rays entering the eye on the retina.

After the natural crystalline lens is removed, for example, because of cataract or other condition, a conventional, monofocal IOL can be placed in the posterior chamber. Such a conventional IOL has very limited, if any, accommodating ability. However, the wearer of such an IOL continues to require the ability to view both near and far (distant) objects. Corrective spectacles may be employed as a useful solution. Recently, multifocal IOLs without accommodating movement have been used to provide near/far vision correction.

Attempts have been made to provide IOLs with accommodating movement along the optical axis of the eye as an alternative to shape changing. Examples of such attempts are set forth in Levy U.S. Patent 4,409,691 and several patents to Cumming, including U.S. Patents

5,674,282 and 5,496,366. The disclosure of each of these patents is incorporated herein by reference. One problem that exists with such IOLs is that they often cannot move sufficiently to obtain the desired accommodation.

It would be advantageous to provide IOLs adapted for accommodating movement which can achieve an increased amount of accommodation.

## Summary of the Invention

New accommodating IOLs have been discovered. The present accommodating IOLs take advantage of employing an optic made including at least two portions to enhance the accommodation achievable in the eye in response to normal accommodative stimuli, for example, while preferably providing substantially normal distance vision with the IOL in a rest or unaccommodated condition. Thus, the present lenses provide for controlled vision correction or focusing for both near objects and far or distant objects. Further, a greater overall range of accommodation is often achieved. The present IOLs are relatively straightforward in construction and to manufacture or produce, can be implanted or inserted into the eye using systems and procedures which are well known in the art and function effectively with little or no additional treatments or medications being required.

In one broad aspect of the present invention, intraocular lenses (IOLs) are provided and comprise an optic adapted to focus light toward a retina of a mammalian eye and, in cooperation with the mammalian eye, to provide accommodation. The optic includes a first lens portion adapted to move in response to the action of the mammalian eye; and a second lens portion secured to the first portion of the optic and positioned generally in a posterior region

of the optic and/or having a baseline diopter power for distance vision.

The first portion is comprised of an optically clear material that is easily reshaped and may also be axially movable, when exposed to forces exerted by the mammalian eye.

In a very useful embodiment, the first lens portion of the optic includes an anterior surface, which often coincides with the anterior face of the optic. The first portion is adapted to be reshaped in response to the action of the mammalian eye. Such reshaping advantageously effects a change in the curvature of the anterior surface of the first portion, or the anterior face of the optic. Such change in curvature changes the optical or diopter power of the optic and, ultimately provides accommodation. The first portion of the optic may additionally be adapted to move axially in the mammalian eye in response to the action of the mammalian eye. Such axial movement may provide an additional degree of accommodation. However, it is preferred that the reshaping of the optic be the primary or major source of accommodating movement of the present optics. For example, such reshaping may result in at least about 50% or at least about 70% or more of the total amount of accommodation to be provided by the present IOLs.

The second lens portion of the optic is comprised of an optically clear material. In one very useful embodiment, the second portion is located generally posterior of the first portion, when the IOL is placed in the eye. Preferably, the second portion includes a posterior surface which defines at least a portion of the posterior face of the optic. The second portion can, however, be totally encased or surrounded by the first portion with the second portion being located generally posterior of the center point of the optic, for example, with the shape of at least a portion of the posterior face

of the optic being substantially the shape of the posterior surface of the second portion, and this embodiment is included within the scope of the present invention. The posterior bias of the second portion is advantageous in allowing the first portion, and in particular the anterior surface of the first portion, to be reshaped to an enhanced extent by the action of the mammalian eye. Such enhanced reshaping results in an enhanced amount of accommodation achieved by the present IOLs.

In a particularly useful embodiment, the second lens portion of the optic has a baseline diopter power for distance vision. Such a baseline diopter power may be considered a zero add power in that this baseline power is such that substantially no positive diopter power beyond the distance vision correction power required by the wearer of the IOL is provided. Thus, when the wearer of the present IOL wishes to see a distant object, the IOL is in an unaccommodated condition and the distance baseline diopter power of the second lens portion of the optic provides the wearer with the ability to see the distant object in focus. The second portion of the present optics advantageously may be monofocal, having a diopter power for distance vision.

The first lens portion of the optic preferably is more deformable than the second lens portion in the eye. That is, the first portion preferably is more easily reshaped or achieves a larger degree of reshaping in the eye in response to the action of the eye than does the second portion. In one useful embodiment, the second portion is substantially rigid, or substantially not reshapable, in response to forces exerted by the eye on the second portion in the eye.

The second lens portion of the present optic may have a higher, lower or the same refractive index relative to the refractive index of the first portion. For example,

both first and second portions of the present optics may have refractive indexes of about 1.37 or less. However, preferably both the first and second portions have refractive indexes of at least about 1.40 and more preferably at least about 1.42.

In another very useful embodiment, a force transfer assembly is provided. This force transfer assembly has a first end coupled to the optic and a second end extending away from the optic and adapted to contact a posterior bag of the mammalian eye when the IOL is located in the mammalian eye. The force transfer assembly is adapted to transfer the force exerted by the eye to the optic to facilitate the movement of the optic. Preferably, the force transfer assembly is adapted to transfer the force exerted by the eye to the optic to facilitate reshaping the first lens portion in response to the action of the mammalian eye, and possibly moving the first portion axially in the mammalian eye in response to the action of the mammalian eye. The force transfer assembly is very effective in facilitating the accommodation obtained by the present IOLs.

However, it should be noted that such force transfer assembly is not essential in accordance with the present invention. The optic can be sized and configured to fit within the capsular bag and to contact the capsular bag, in particular the periphery of the capsular bag, so that the force exerted by the eye can be transferred directly to the optic of the present IOL. Such IOLs in which the optics are sized and configured to contact the peripheral capsular bag are very effective in being reshaped to provide the desired accommodation. In addition, substantially filling the capsular bag volume with an optic including a reshapable first lens portion and a second lens portion as in the present optics, reduces the risk of decentration or tilt of the lens system in the eye, as well as reducing the

risk of decentration or tilt between individual lens components, relative to lens systems in which the optic does not substantially fill the capsular bag volume. Providing for a reduced risk of decentration is highly advantageous, for example, as the capsular bag compresses or contracts. Even if the contraction of the capsular bag is asymmetric, for example, because the zonules are not of uniform strength, the elastic properties of the first lens portion mitigate against this asymmetry and reduce the risk of decentration.

Substantially filling the capsular bag volume, as described above, may reduce the risk of posterior capsular opacification (PCO) particularly if the posterior surface of the optic remains in contact with the posterior wall of the capsular bag during all states of accommodation.

In a very useful embodiment, the present IOLs are deformable for insertion into the mammalian eye through a relatively small incision, for example on the order of about 3.5 mm or less. Thus, both the first and second lens portions of the optic, and/or the force transfer assembly, if present, are all deformable for insertion through a small incision into the eye. Such IOLs regain their original undeformed condition rapidly after being inserted into the mammalian eye.

The present optics may be made of any suitable materials of construction. For example, the present optics may be made of one or more polymeric materials employing techniques used in manufacturing conventional polymeric material IOLs. Examples of the materials from which the present optics can be made include, without limitation, acrylic polymeric materials, silicone polymeric materials, and the like and combinations thereof. Although combinations of different polymeric materials may be employed, the present optics preferably are made of different polymeric materials of the same general chemical

family. For example, the first lens portion of the optic may be made of one silicone polymeric material while the second lens portion is made of a different silicone polymeric material. Similarly, the first lens portion of the optic can be made of one acrylic polymeric material while the second lens portion is made of a different acrylic polymeric material. The first lens portion and the second lens portion of the present optics preferably are made of compatible materials of construction, that is materials which can be used to produce an effective IOL which remains as an intact structure in the eye without significant deterioration for periods of time extending for at least about 20 or about 25 years or more.

In one embodiment, the first lens portion of the present optics is made of a very low modulus silicone polymeric material, while the second portion is made of a higher modulus silicone polymeric material. To illustrate, the first lens portion of the optic can be composed of a silicone polymeric elastomer with the following material properties:

Optically clear;
Refractive index of at least about 1.37 or at least about 1.40 or higher;
Shore A hardness of about 0; and
At least about 1000% elastic elongation.

The second lens portion of the present optics can be made of a different silicone elastomer with the following material properties:

Optically clear;
Refractive index of at least about 1.40 or at least about 1.42 or higher;
Shore A hardness in a range of about 0 to about 30; and

An elastic elongation higher than about 150%, preferably in a range of about 150% to about 400%.

The second lens portion can be made of widely varying materials. Examples include, without limitation, rigid and foldable acrylic polymeric materials, rigid and foldable non-acrylic polymeric materials, deformable or foldable silicone polymeric materials and the like and combinations thereof. The second lens portion can be hydrophobic or hydrophilic.

Many materials which meet the above-noted criteria are conventional and well known in the art. Therefore, a detailed description of such compositions is not presented here.

However, by way of illustration, the following materials of construction, based on constituent monomeric components, is presented.

**TABLE**

**POTENTIAL FORMULATIONS**

| Component | First Portion | Second Portion |
|---|---|---|
| 2-phenylpropyl acrylate 2-phenylpropyl methacrylate | 50% wt. | 70% wt. |
| Ethylene glycol dimethacrylate | 0.5% wt. | 1.0% wt. |
| N-hexyl acrylate | 48.9% wt. | 28.4% wt. |
| UV chromophore (benzotriazole-type) | 0.5% wt. | 0.5% wt. |
| Initiator | 0.1% wt. | 0.1% wt. |

The present optics are conveniently produced using conventional and well known techniques, such as molding techniques. In one embodiment, the second lens portion is

produced in a separate mold and then inserted into a mold into which is placed the monomeric or partially polymerized monomeric mixture of the first lens portion precursors. The combination is then heated to elevated temperatures, for example on the order of about 40°C to about 100°C, and/or subjected to ultraviolet radiation and the composition combination is allowed to cure, preferably for about one hour to about 24 hours. The material in the mold is then post-cured, preferably at a temperature in the range of about 70°C to about 130°C, and/or by being subjected to ultraviolet radiation for a period of time, preferably for about two hours to about 30 hours. After curing (and post-curing), the mold is disassembled and the molded lens body or optic recovered.

The force transfer assembly, if present, can be made or provided separately and then coupled to the optic or lens body, for example, in a mold in which the optic is cured or post-cured. Alternately, the force transfer assembly can be coupled to the lens body after the lens body is formed. Conventional techniques can be employed. For example, one or more recesses can be formed in the optic and the force transfer assembly can be secured to the optic by having an end placed in the recess, for example, in much the same manner in which a haptic or fixation member is secured to the optic of a conventional IOL.

Any suitable material or combination of materials of construction may be utilized in the force transfer assembly and the force transfer assembly can have any suitable configuration provided that such assembly is effective to at least partially transfer the force of the eye to the optic of the IOL. The force transfer assembly preferably is more rigid or less flexible than the first lens portion of the optic. However, the force transfer assembly preferably is sufficiently deformable to be folded or otherwise deformed to pass through a small incision for

insertion into the eye. The force transfer assembly can be a single member substantially surrounding the optic, or can be a plurality, for example, about 2 or about 3 to about 4 or about 6, individual elements positioned around the peripheral edge of the optic. Although the force transfer assembly can include at least one hinge to facilitate axial movement of the optic in response to the action of the eye, preferably the force transfer assembly does not include a hinge.

The force transfer assembly preferably is made of a material or materials which are compatible with the eye and with the other material or materials included in the IOL. Examples of materials which can be included in the present force transfer assemblies include, but are not limited to, polypropylene, silicone polymeric materials, acrylic polymeric materials including but not limited to polymethylmethacrylate (PMMA), polyamides and the like and combinations thereof.

In a further broad aspect of the present invention, methods for inserting an IOL in an eye are provided. Such methods comprise providing an IOL in accordance with the present invention, as described herein. The IOL is placed into the eye, for example in the capsular bag of the eye, using equipment and techniques which are conventional and well known in the art. The IOL is placed in the eye so that the eye effectively cooperates with the IOL to provide accommodation as desired. After the IOL is inserted into the eye, any incision in the eye is closed. After a relatively short period of recuperation, the IOL provides the wearer of the IOL with substantially effective accommodation. No further treatments or medications, for example, to paralyze the ciliary muscle, to facilitate fibrosis or otherwise influence the position of the IOL in the eye, are required. Preferably the optic is deformed prior to being placed into the eye. Once the IOL is placed

in the eye, and after a normal period of recovery from the surgical procedure, the IOL, in cooperation with the eye, provides the mammal or human wearing the IOL with the desired accommodation.

Any and all features described herein and combinations of such features are included within the scope of the present invention provided that the features of any such combinations are not mutually inconsistent.

Additional aspects and advantages of the present invention are set forth in the following description and claims, particularly when considered in conjunction with the accompanying drawings in which like parts bear like reference numerals.

## Brief Description of the Drawings

Fig. 1 is a perspective view of an IOL in accordance with the present invention with the posterior face of the optic shown facing up;

Fig. 2 is a fragmentary sectional view of an eye in which the IOL of Fig. 1 has been implanted, with the lens being located in a resting position with the ciliary muscle of the eye in the relaxed state;

Fig. 3 is a fragmentary sectional view of an eye in which the IOL of Fig. 1 has been implanted, with the ciliary muscle of the eye in the contracted state;

Fig. 4 is a perspective view of an additional IOL in accordance with the present invention with the posterior face of the optic shown facing up;

Fig. 5 is a fragmentary sectional view of an eye in which the IOL of Fig. 4 has been implanted with the lens being located in a resting position with the ciliary muscle of the eye in the relaxed state;

Fig. 6 is a fragmentary sectional view of an eye in which the IOL of Fig. 4 has been implanted, with the ciliary muscle of the eye in the contracted state.

Detailed Description of the Drawings

Referring now to Figs. 1, 2 and 3, an IOL according to the present invention, shown generally at 10, includes a lens body or optic 12. This optic 12 includes a posterior lens portion 14 and an anterior lens portion 16.

The posterior lens portion 14 is made of an optically clear material with a refractive index of at least about 1.42, for example, about 1.48. The posterior lens portion 14 can be either deformable or rigid. Preferably the posterior lens portion 14 is sufficiently deformable so as to be foldable or otherwise deformed for insertion into the eye through a small incision, that is an incision in the eye smaller than the maximum, undeformed diameter of the optic 12. However, the posterior lens portion 14 preferably is more rigid than is the anterior lens portion 16.

The anterior lens portion 16 is comprised of an optically clear material that is easily deformable when subjected to the action of the eye. The anterior lens portion 16 can have substantially the same or a different, for example, somewhat reduced, higher refractive index relative to the refractive index of the posterior lens portion 14 of optic 12.

The posterior lens portion 14 and the anterior lens portion 16 preferably are comprised of materials from the same basic chemical family. For example, the anterior lens portion 16 may be comprised of low or very low modulus silicone polymeric material, while the posterior lens portion 14 can be comprised of a different silicone polymeric material. The modulus of the silicone polymeric

material making up the anterior lens portion 16 is, for example, no greater than about 20 psi.

Alternately, the anterior lens portion 16 can be comprised of a hydrophilic acrylic polymeric material, while the posterior lens portion 14 can be made of relatively high refractive index, rigid or deformable (for insertion) acrylic polymeric material which can be either hydrophobic or hydrophilic.

One example of the materials used to produce the anterior lens portion 16 and the posterior lens portion 14 are as follows:

TABLE

POTENTIAL FORMULATIONS

| Component | Anterior Portion | Posterior Portions |
|---|---|---|
| 2-phenylpropyl acrylate 2-phenylpropyl methacrylate | 50% wt. | 70% wt. |
| Ethylene glycol dimethacrylate | 0.5% wt. | 1.0% wt. |
| N-hexyl acrylate | 48.9% wt. | 28.4% wt. |
| UV chromophore (benzotriazole-type) | 0.5% wt. | 0.5% wt. |
| Initiator | 0.1% wt. | 0.1% wt. |

The present IOL 10 can be produced using conventional polymer processing techniques. For example, the present posterior lens portion 16 can be produced separately using conventional molding, for example, injection molding, techniques. This lens portions 14 can then be used to produce optic 12 using conventional molding techniques, for example, insert molding techniques, together with the material used to produce the anterior lens portion 16.

The optical powers of the lens portions 14 and 16 may be controlled so as to satisfactorily address the needs of

the patient in whose eye IOL 10 is inserted. Each of the lens portions 14 and 16 can have a suitable optical power.

In one particularly useful embodiment, the posterior lens portion 14 has a baseline diopter power for distance vision. For example, the posterior lens portion 14 may be substantially monofocal, having a diopter power for distance vision. Providing the posterior lens portion with a diopter power for distance vision effectively allows the wearer of IOL 10 to see distant objects in focus with the IOL located in the eye in the unaccommodated state, that is in the resting state, as generally shown in Fig. 2.

The IOL 10 is sized to fit within the capsular bag 50 of the eye 40 so as to be reshapable in response to the action of the eye. The IOL 10 should be sized to facilitate the movement and reshaping of the optic 12 in response to the action of the eye. For example, if the optic 12 is too large, the ciliary muscle 46 will be inhibited from effectively contracting/relaxing so that the amount of accommodating movement, e.g., reshaping, will be unduly restricted. Of course, if the IOL 10 is too small, the optic 12 will be ineffective to focus light on the retina of the eye 40, may cause glare and/or may not cooperate with the eye to effect the desired amount of accommodation. If the IOL 10 is to be included in an adult human eye, the optic 12 preferably has a diameter in the range of about 8 mm to amount 12 mm.

The IOL 10 can be inserted into the capsular bag 50 of the eye 40 using conventional equipment and techniques, for example, after the natural crystalline lens of the eye is removed, using a phacoemulsification technique.

The IOL 10 in the eye 40, as shown in Figs. 2 and 3, is located so that the posterior surface 20 of the anterior lens portion 16 and the posterior surface 22 of the posterior lens portion 14 are in contact with the inner posterior wall 52 of the capsular bag 50. The posterior

surfaces 20 and 22 together make up the posterior face 24 of optic 12 which is in contact with the inner posterior wall 52 of the capsular bag 50. This contact is substantially maintained regardless of the configuration of the optic 12 in the eye 40. Such contact is effective in maintaining the structural integrity of the capsular bag 50 and, in addition, effectively inhibits the growth of cells from the capsular bag onto the optic, thereby at least inhibiting or reducing the severity of posterior capsular bag opacification (PCO).

The eye 40, for example, the zonules 48 and the ciliary muscle 46 of the eye, are effective to move or compress the capsular bag 50, thereby reshaping the optic 12. In addition, some axial movement of optic 12 may occur in response to the action of the eye 40.

Without wishing to limit the invention to any particular theory or mode of operation, the eye 40 is believed to act on optic 12 as follows. With the ciliary muscle 46 fully relaxed, the tension of the zonules 48 causes the capsular bag 50 to increase in diameter which, in turn, causes optic 12 to become relatively thin. Such configuration of optic 12 provides effective distance vision to the eye 40. This configuration is at least generally illustrated in Fig. 2. With IOL 10 in the position as shown in Fig. 2, far away or distant objects are brought into focus. If a near object is to be viewed, the ciliary muscle 46 contracts or constricts. The capsular bag 50 compresses, reshaping the optic 12 included therein, as shown in Fig. 3. This reshaping of the optic 12 causes the anterior face 30 of the anterior lens portion 16 to become more curved, thereby increasing the optical power of the optic 12. This reshaping of optic 12 provides near focus accommodation to allow the near object to be viewed.

The present IOL 10 has the ability, in cooperation with the eye, to be reshaped to provide for both distance focus and near focus.

IOL 10 is such that the amount of accommodation achievable preferably is in the range of about 1 to about 4 or about 5 or about 6 diopters.

Figs. 4, 5 and 6 illustrate an additional IOL, shown generally at 110, in accordance with the present invention. Except as expressly described herein, additional IOL 110 is structured and functions similarly to IOL 10. Components of IOL 110 which correspond to components of IOL 10 are indicated by the same reference numerals increased by 100.

The primary difference between IOL 110 and IOL 10 relates to the presence in IOL 110 of a force transfer assembly, shown generally at 70. In particular, as best shown in Fig. 4, force transfer assembly 70 includes four identically structured transfer members 72 which extend radially outwardly from the proximal end 74, which is attached to optic 112, to an outer or distal end 76. Each of the transfer members 72 has a substantially flat configuration and is made of an acrylic polymeric material which is deformable for insertion of the IOL 110 into the eye, yet is more rigid than the anterior lens portion 116 to facilitate the transfer of force from the eye 140 to the optic 112. One particularly useful acrylic polymeric material for use as a material of construction of the members 72 is a polymeric composition produced from the following mixture of monomers:

| | |
|---|---|
| Ethyl acrylate | 57.1% by weight |
| Ethyl methacrylate | 27.7% by weight |
| Trifluoroethyl methacrylate | 9.8% by weight |
| Ethylene glycol dimethacrylate | 3.8% by weight |
| UV chromophore | 1.5% by weight |
| Initiator (thermal) | 0.1% by weight |

The IOL 110 can be produced by injection molding the posterior lens portion 114 and transfer members 72 separately and then insert molding can be employed to form the combination of the posterior lens portion, the transfer members and the anterior lens portion 116.

With the force transfer assembly 70 in place, if the IOL 110 is to be included in an adult human eye, the optic 112 preferably has a diameter in the range of about 3.5 mm to about 7 mm, and the IOL 110 has an overall maximum diameter, including the force transfer assembly 70 in the rest state, that is fully extended from the optic 112, in the range of about 8 mm to about 12 mm.

Insertion can be accomplished using conventional techniques, for example, after the natural lens of the eye has been removed.

In the eye 140, the optic 112 is reshaped in response to the action of the eye, which includes ciliary muscles 146 and zonules 148, through force transfer assembly 70. The posterior surface 122 of optic 112 remains in substantial contact with the inner posterior wall 152 of the capsular bag 150. Such contact inhibits the growth of cells from the capsular bag 150 onto optic 110 and inhibits PCO.

IOL 110 provides focus accommodation because of the reshaping of the optic 112, in much the same way as when optic 12 is reshaped, for example, by changing the curvature of anterior face 130. However, optic 112 provides further accommodation because of the axial movement of optic 112. Thus, optic 112 may provide additional or enhanced accommodation relative to optic 12.

The present invention provides accommodating IOLs which cooperate with the eye to achieve advantageous amounts, preferably enhanced amounts, of accommodation. Such accommodation, as described herein, is often

increased, for example relative to previous accommodating IOLs. In the resting or unaccommodated state in the eye, the present IOLs advantageously are effective to provide distance vision.

While this invention has been described with respect to various specific examples and embodiments, it is to be understood that the invention is not limited thereto and that it can be variously practiced within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An intraocular lens for use in a mammalian eye comprising:

an optic adapted to focus light toward a retina of the mammalian eye and, in cooperation with the mammalian eye, to provide accommodation, the optic including

a first lens portion adapted to move in response to the action of the mammalian eye; and

a second portion secured to the first lens portion and positioned generally in a posterior region of the optic.

2. The intraocular lens of claim 1 wherein the first lens portion includes an anterior surface and is adapted to be reshaped in response to the action of the mammalian eye, the reshaping being effective to change the curvature of the anterior surface.

3. The intraocular lens of claim 1 wherein the first lens portion is adapted to move axially in the mammalian eye in response to the action of the mammalian eye.

4. The intraocular lens of claim 1 wherein the optic includes a posterior face and the second portion includes a posterior surface which defines at least a portion of the posterior face of the optic.

5. The intraocular lens of claim 1 wherein the second lens portion has a baseline diopter power for distance vision.

6. The intraocular lens of claim 1 wherein the second lens portion is monofocal, having a diopter power for distance vision.

7. The intraocular lens of claim 1 wherein the optic is deformable for insertion into the mammalian eye through a small incision.

8. The intraocular lens of claim 1 wherein the first lens portion is more deformable than the second lens portion.

9. The intraocular lens of claim 1 wherein the second lens portion is substantially rigid in response to forces exerted on the second lens portion in the eye.

10. The intraocular lens of claim 1 which further comprises a force transfer assembly having a first end coupled to the optic and a second end extending away from the optic and adapted to contact a posterior bag of the mammalian eye when the intraocular lens is located in the mammalian eye, the force transfer assembly being adapted to transfer the force exerted by the eye to the optic to facilitate the movement of the optic.

11. The intraocular lens of claim 10 wherein the force transfer assembly is adapted to transfer the force exerted by the eye to the optic to facilitate reshaping the first lens portion in response to the action of the mammalian eye.

12. The intraocular lens of claim 1 wherein the optic comprises materials selected from the group consisting of acrylic polymeric materials and silicone polymeric materials.

13. The intraocular lens of claim 1 wherein the first lens portion and the second lens portion are made of compatible materials.

14. The intraocular lens of claim 13 wherein the first lens portion and the second lens portion are made of different polymeric materials of the same general chemical family.

15. An intraocular lens for use in a mammalian eye comprising:

an optic adapted to focus light toward a retina of the mammalian eye and, in cooperation with the mammalian eye, to provide accommodation, the optic including

a first lens portion adapted to move in response to the action of the mammalian eye; and

a second portion secured to the first lens portion and having a baseline diopter power for distance vision.

16. The intraocular lens of claim 15 wherein the first lens portion includes an anterior surface and is adapted to be reshaped in response to the action of the mammalian eye, the reshaping being effective to change the curvature of the anterior surface.

17. The intraocular lens of claim 15 wherein the first lens portion is adapted to move axially in the mammalian eye in response to the action of the mammalian eye.

18. The intraocular lens of claim 15 wherein the second lens portion is monofocal, having a diopter power for distance vision.

acrylic polymeric materials and silicone polymeric materials.

26. The intraocular lens of claim 1 wherein the first portion comprises a material selected from the group consisting of hydrophobic acrylic polymeric materials and low modulus silicone polymeric materials, and the second portion comprises a material selected from the group consisting of hydrophobic polymeric materials and hydrophilic polymeric materials.

27. The intraocular lens of claim 15 wherein the first portion and the second portion are made of compatible materials.

28. The intraocular lens of claim 27 wherein the first portion and the second portion are made of different polymeric materials of the same general chemical family.

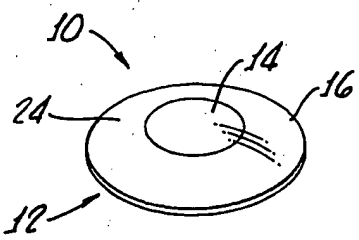



FIG. 1.

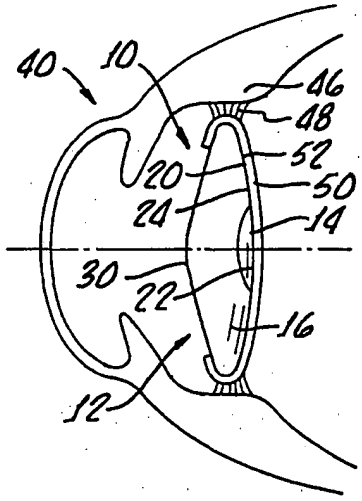



FIG. 2.

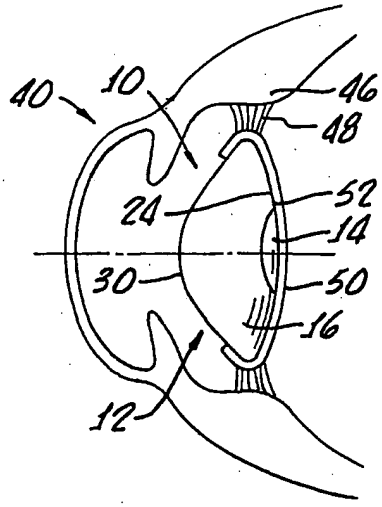



FIG. 3.

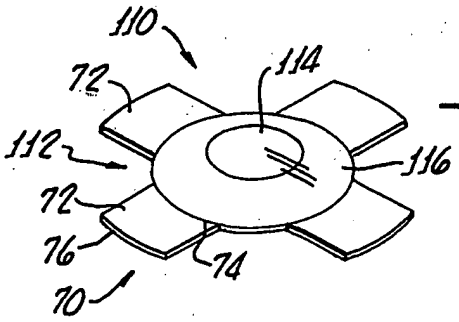



FIG. 4.

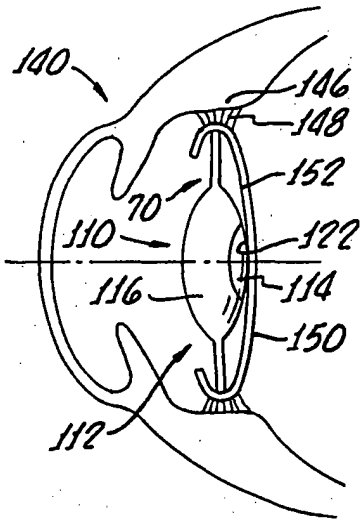



FIG. 5.

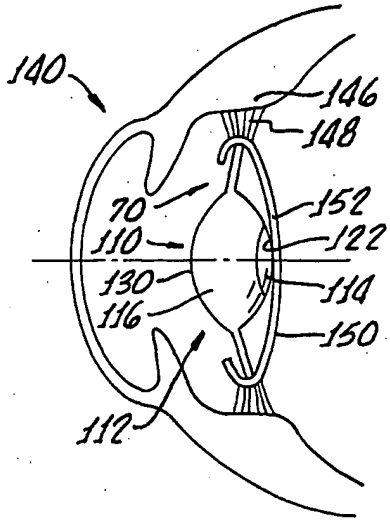



FIG. 6.